

Fundamentals of Nanoelectronics

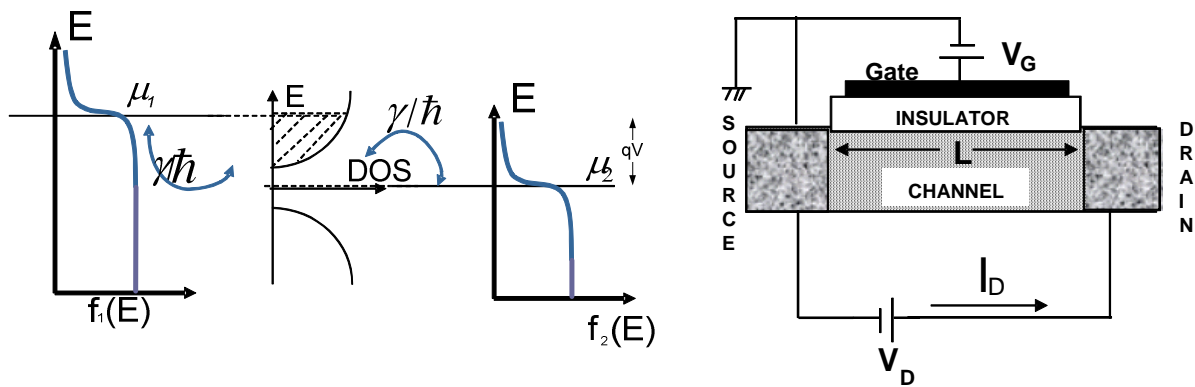
ECE495 - Session 12, Sept 21, 2009

Single vs. Multi Electron Picture

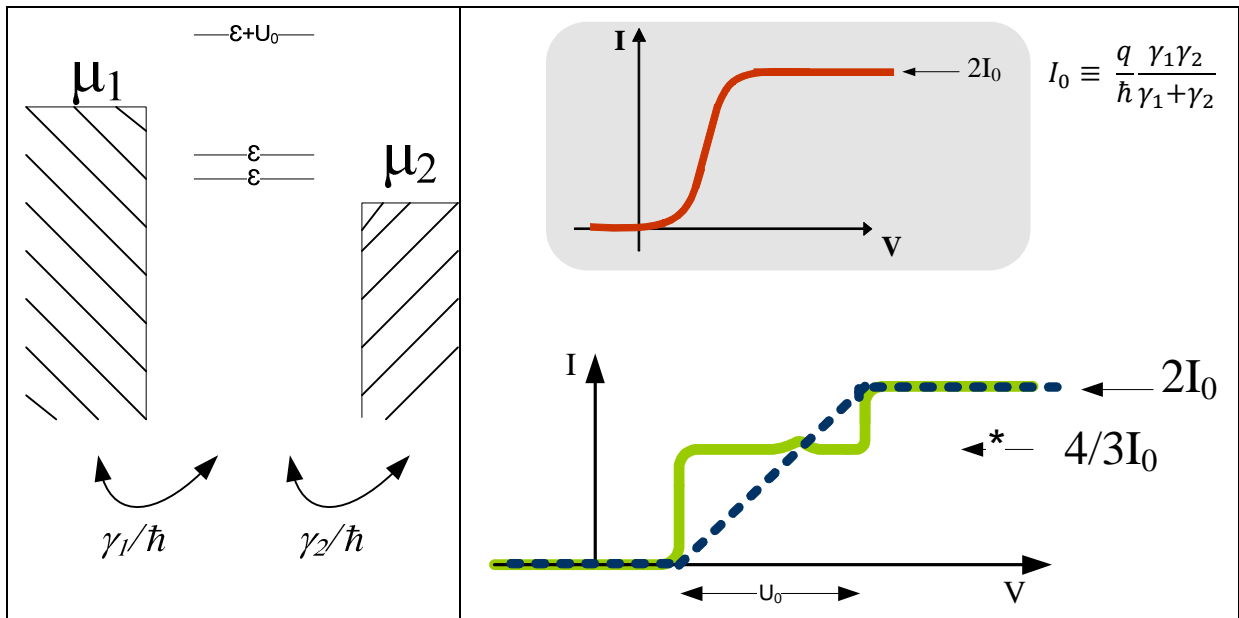
Ref: Chapter 3.4

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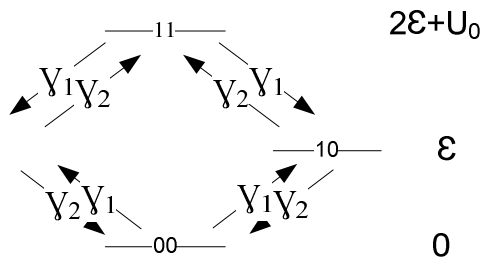
One-electron picture



If $k_B T + \gamma_1 + \gamma_2 \gtrsim U_0$ then we can use SCF method

Else $k_B T + \gamma_1 + \gamma_2 \ll U_0$ we cannot use SCF method.

Multi-electron picture



If we have N level between μ_1 and μ_2 then 2^N states we will have in multi electron picture.

In steady state when $\epsilon < \mu_1 < 2\epsilon + U_0$, rate equation:

$$\frac{a}{b} = \frac{c}{d} \rightarrow \frac{a}{a+b} = \frac{c}{c+d}$$

$$P_{00} \cdot 2\gamma_1 = P_{01} \cdot \gamma_2 + P_{10} \cdot \gamma_2$$

$$\frac{P_{01} + P_{10}}{P_{00}} = \frac{2\gamma_1}{\gamma_2} \rightarrow \frac{P_{01} + P_{10}}{1} = \frac{2\gamma_1}{2\gamma_1 + \gamma_2} \& P_{00} = \frac{\gamma_2}{2\gamma_1 + \gamma_2}$$

In *,

$$I = \frac{q}{\hbar} \frac{2\gamma_1\gamma_2}{2\gamma_1 + \gamma_2} \text{ if } \gamma_1 = \gamma_2 \text{ then } I = \frac{q}{\hbar} \frac{2\gamma_1}{3} \text{ and as } I_0 = \frac{q}{\hbar} \frac{\gamma_1}{2} \Rightarrow I = \frac{4}{3} I_0$$

In steady state when $\mu_1 > 2\epsilon + U_0$, rate equation:

$$P_{00} \cdot 2\gamma_1 = P_{01} \cdot \gamma_2 + P_{10} \cdot \gamma_2$$

$$P_{11} \cdot 2\gamma_2 = P_{01} \cdot \gamma_1 + P_{10} \cdot \gamma_1$$

$$P_{00} = (P_{01} + P_{10}) \frac{\gamma_2}{2\gamma_1} = \left(\frac{\gamma_2}{\gamma_1 + \gamma_2} \right)^2$$

$$P_{11} = (P_{01} + P_{10}) \frac{\gamma_1}{2\gamma_2} = \left(\frac{\gamma_1}{\gamma_1 + \gamma_2} \right)^2$$

$$P_{01} + P_{10} = \frac{2\gamma_1\gamma_2}{(\gamma_1 + \gamma_2)^2}$$

$$P_{01} + P_{10} \equiv X \rightarrow 1 = X + X \frac{\gamma_2}{2\gamma_1} + X \frac{\gamma_1}{2\gamma_2}$$

$$X = \frac{1}{1 + \frac{\gamma_2}{2\gamma_1} + \frac{\gamma_1}{2\gamma_2}} = \frac{2\gamma_1\gamma_2}{2\gamma_1 + \gamma_1^2 + \gamma_2^2}$$